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THE PRODUCTIVITY AND QUALITY OF SEMI-NATURAL GRASSLAND SWARD, DEPENDING ON THE NUMBER OF CUTS

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Abstract. The aim of this study was to analyze the dynamics of the yield of mown but unfertilized meadows, in the southern part of Poland, in the period of 2011–2013. For this field research, there were established 4 experimental plots, which were cut respectively: once, twice, three and four times a year. Furthermore, dry matter yield, crude protein, crude fibre and the yield of the root mass were evaluated. That concerned both above ground dry matter yield and root dry mass, from the studied sites. However, at a probability level of p=0.011, there has been seen the effect of the number of cuts on the total yield of dry mass, depending on the year. Still, there were no significant differences between the mean contents of total protein (p=0.233) and crude fibre (p=0.252) during the study, whereas in the low probability test (p<0.001) significant differences between mean levels of these components depending on the number of cuts were showed.

Key words: botanical composition, dry matter yield, root mass, crude protein (CP), crude fiber (CF)

INTRODUCTION

The economic transformation of the 1990s in Central Europe, has contributed to many changes in the agricultural sector. In Poland, unfavourable economic conditions have given rise to the abandonment of many areas, once used for agriculture [Radkowski et al. 2005]. Since that time, severely reduced agrotechnical treatments, as well as the cessation of fertilization on many permanent grasslands, have been observed especially in southern part of Poland [Zarzycki and Szewczyk 2013]. This situation was mainly the result of the decrease of the livestock's number. The extensification of agricultural production, which is characterized by a low input farming and connected with the abandonment of fertilization or sheep grazing, was often observed in polish mountainous areas [Musiał and Kasperczyk 2013]. Such extensification or even abandonment of usage, induced certain changes in formerly highly productive ecosystems and areas which have been deprived of human impact, are prone to undergo distinct transformations. Therefore, changes refer not only to the quantity and quality of forage, but also to the floristic composition of such grassland communities.

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Also in the more developed countries of the European Union, semi-natural meadows are often excluded from use for the economic reasons, or just converted into extensive grasslands [Heinsoo et al. 2010, Poschlod et al. 2005, Römermann et al. 2009]. Yet, semi-natural plant communities play many important functions in the environment, e.g. in shaping landscape and are usually very valuable in terms of their floristic diversity [Wallis De Vries et al. 2002, Musiał and Kasperczyk 2013, Musiał et al. 2015]. Therefore, the EU Council Directive introduces the obligation to keep those areas in good agricultural and environmental conditions. According to some authors, with a view to keep biodiversity in those ecosystems, mowing rather than grazing is recommended [Hansson and Fogelfors 2000, Sammul et al. 2000, Schaffers 2002]. On the other hand, the intensity of usage of those areas is also important [Donath et al. 2004, Sammul et al. 2008].

It is widely recognized, that the number of cuts and fertilization, have a significant impact respectively on: yield, forage quality and botanical composition of semi-natural grasslands [Grygierzec and Musiał 2013, Nevens and Rehuel 2003]. Yet, relatively little is still known about the effects of using (mowing frequency) on the root mass of species occurring in semi-natural grasslands [Vinther 2006]. Moreover, the nutritional value of fodder obtained from grasslands, without previous fertilization, requires further examination. Furthermore, some of the researchers are looking for newer and more effective solutions for grasslands, such as replacement of nitrogen fertilizers by the biological fertilizers [Jankowski et al. 2014]. According to Donath et al. [2004] and Sammul et al. [2008], extensive use provides a high natural value for meadows. Bruinenberg et al. [2006], goes even one step further, recommending silage from semi-natural grassland in the diet of dairy cows during lactation, without reducing their productivity. Taking into account the specificity of farming on permanent grasslands in Central Europe, especially in southern Poland, some opportunities to maintain or even increase the areas of such grasslands have lately appeared. It is connected with functioning in the EU countries the structure of Common Agricultural Policy. It gives some opportunities to participate in so called agri-environmental schemes, where farmers are obliged to conduct extensive land usage. Hence, some studies concerning the potential of production and fodder quality, that come from semi-natural permanent grasslands, should have been undertaken.

Thorough knowledge about the grassland productivity requires comprehensive and insightful research, which is also an important part of their optimization [Oomes 1990]. That is why, the intention of authors of this study, was to demonstrate the quantitative (dry weight of the above ground and root biomass of plants) and the qualitative (protein and fibre content) changes in the sward of semi-natural meadows, in the period of three years, depending on the frequency of mowing, without the usage of any artificial fertilizers.

MATERIAL AND METHODS

The study was conducted from 2011 to 2013 in Śnietnica (49°53′ N and 21°07′ E), in the mountainous area of the Beskid Niski subregion [Kondracki 2009]. The experiment was established on permanent grasslands, that used to be cut once a year, without using any fertilizers in the period of eight years, that had preceded the research. Experimental plots were located at an altitude of about 650 m a.s.l. Plant cover was characterized according to Matuszkiewicz [2002], as a combination of two communities, *Gladiolo-Agrostietum capillaris* and *Anthyllidi-Trifolietum montani*, with the dominance of *Agrostis capillaris* L.

The experiment was carried out in a randomized block design with four replications, the plots covered an area of 20 m^2 (4 m x 5 m). During the study period, no fertilizers were applied on the grasslands. Plants were cut at a height of 5 cm. The meadows' sward was cut in the following scheme: plots cut once (harvesting between 15th and 20th of June), plots cut twice (1st cut between 10th and 15th of June, 2nd cut after 60 days), plots cut three times (1st cut between 2nd and 5th of June, 2nd after 45 days, 3rd in another 45 days), and plots cut 4 times (1st cut between 25th and 28th of May, 2nd, 3rd and 4th in 35 day interval each).

The experimental plots were located on acid brown soils (*cambisols*), with a mechanical composition of medium clay, and a relatively well-developed soil profile [Bednarek et al. 2009]. The chemical properties of the soil are shown in Table 1.

Table 1. The soil chemical properties

Specification		In the 0–10 cm layer	In the 10–20 cm layer
pH_{KCl}		4.39	4.52
pH_{H2O}		4.85	4.96
Organic matter (g·kg^{-1} of soil)		18.3	15.3
N_{total} (g·kg^{-1})		1.59	1.47
The content of available (mg·kg^{-1} of soil)	P	17.2	19.2
	K	46.3	41.5
	Mg	39.5	41.2

Chemical analyses of the soil samples (mixture of four repetitions) were performed according to several methods. Firstly, there were assessed pH in 1 mol·dm^{-3} KCl by potentiometric method and content of organic carbon by Tiurin method, modified by Oleksynowa et al. [1993]. Then, total nitrogen content was assessed thanks to the Kjeldahl method [AOAC 2003], with the use of the Kjeltec apparatus. Next, available phosphorus by the Egner-Riehm colorimetric method, available potassium using the Egner-Riehm flame photometry, and available magnesium by atomic absorption spectrometry AAS, after extraction with 0.0125 mol·dm^{-3} $CaCl_2$.

The botanical composition of the sward was evaluated before the harvesting of the first cut, by using the Stebler-Schröter method. The yield of the sward was measured by cutting the plants on a 1 m^2 area, in each object. The biomass was weighed, and then dried at 105°C to the constant weight, to determine the content of dry matter (DM), by using the gravimetric method. Subsequently, the plants were ground and chemically analyzed. The total nitrogen content was measured by using the Kjeldahl method, then the results were multiplied by 6.25 to obtain the crude protein content. The content of crude fibre (CF) was estimated by using the Weenden method [AOAC 2003]. In the autumn during the years 2011 and 2013, samples from the area of 30 cm^2, at a the depth of 0–40 cm, in each object (plants with soil), were dissected from the soil profile. Root mass was thoroughly cleaned off the soil and dried at 105 °C to constant weight, to determine the content of root dry matter (RDM).

Total annual precipitation over the three years of research ranged from 613.2 to 752.8 mm [www.tutiempo.net/clima/polonia] and during the growing seasons it reached 404.2–544.8 mm. The average annual temperature ranged from 8.9 to 9.0°C, whereas during the growing seasons it was between 15.1 and 15.7°C. Moreover, the amplitude of the temperature in the vegetation period was from 11.3 to 11.5°C. In the period of 1994–2013, average annual precipitation reached 719.0 mm, and 498.0 mm during the vegetation periods. The average annual temperature in this period was 7.9°C, whereas during the growing season it was 14.1°C.

Statistical analysis was performed using STATISTICA (version 10.0) software. The effects and interactions were tested using ANOVA. A p-value less than 0.05 indicates statistically significant dependencies. Regression models were estimated using the classical method of least squares.

RESULTS AND DISCUSSION

During the first year of the study, in the sward of those experimental plots, which were cut twice and three times, grasses prevailed (49%). At the same time, in the sward that was cut only once a year, but also for that, which was cut four times a year, generally dominated species of dicotyledons (48 and 50%) (Fig. 1). The share of legumes (*Fabaceae* family), in the sward ranged from 4 to 5%. As a result of mowing, in the second year of the study, the share of particular fractions in the sward have slightly changed. In the sward of that sites that were cut two and three times, grasses still prevailed, while the share of *Fabaceae* decreased and other dicotyledons increased. In the sward of the plots, that have been cut four times per year, an increase in the proportion of grass fraction has been noticed, while the amount of dicotyledons remained unchanged (48%). Moreover, the sward of plots which were cut once, was covered by grasses, although there was a minor increase of species from the *Fabaceae* family.

All the changes, that have been observed in particular years, between different number of cuts, were minor (1% within a fraction). However, in the third year of the study, a greater amount of grasses was found in the sward of those plots, which were cut twice, three times and four times, and because of that, there were smaller amounts of other dicotyledons. Moreover, the *Fabaceae* family did not change its share in the sward of plots in particular years, which have been cut twice and three times. Furthermore, sward that was cut most intensively (4 times), consisted of a smaller amount of legumes species, comparing to the previous ones. Furthermore, in the sward which was cut once, the number of other dicotyledons increased, while there was a visible reduction in the fraction of *Fabaceae*. Also during the course of the fieldwork, only small changes have been found in the amount of individual fractions of plants. They were ranging from 1 to 2% between particular experimental plots.

The results of meadow's dry matter yield obtained from this experiment, are compliant with the results of research that was carried out by Kopeć [2000], in the adjacent area. According to his research, which was conducted in the Beskid Sądecki subregion, on unfertilized semi-natural meadows, located at an altitude of about 720 meters above sea level, average dry matter yields did not exceed 3.0 $t \cdot ha^{-1}$, and were mainly dependent on the type of plant community. However, in our study, the yielding of a one-cut meadow ranged from 2.26 to 2.71 t of $DM \cdot ha^{-1}$ (Fig. 2). The yield of a sward which was cut twice, three times and four times, ranged from 2.17 $t \cdot ha^{-1}$ DM to 2.81 $t \cdot ha^{-1}$, and it was close to the yield of the sward that was cut only once a year. The calculated relative standard deviation of the dry matter yields of sward, were variable in subsequent sites and years of the study (Table 2). The greatest diversity of the dry matter yields, around the average (RSD=0.16), were found in the sites, which were cut four times in the second year, and the smallest (RSD=0.03) in those which were cut four times, in the first year of the study.

Furthermore, according to Smoroń [2013], the yield variability of unfertilized meadows, situated in other polish mountainous area, at an altitude of 550–750 meters a.s.l., was dependent and significantly correlated with the particular years of the research (r=0.74). After 25 years of du-

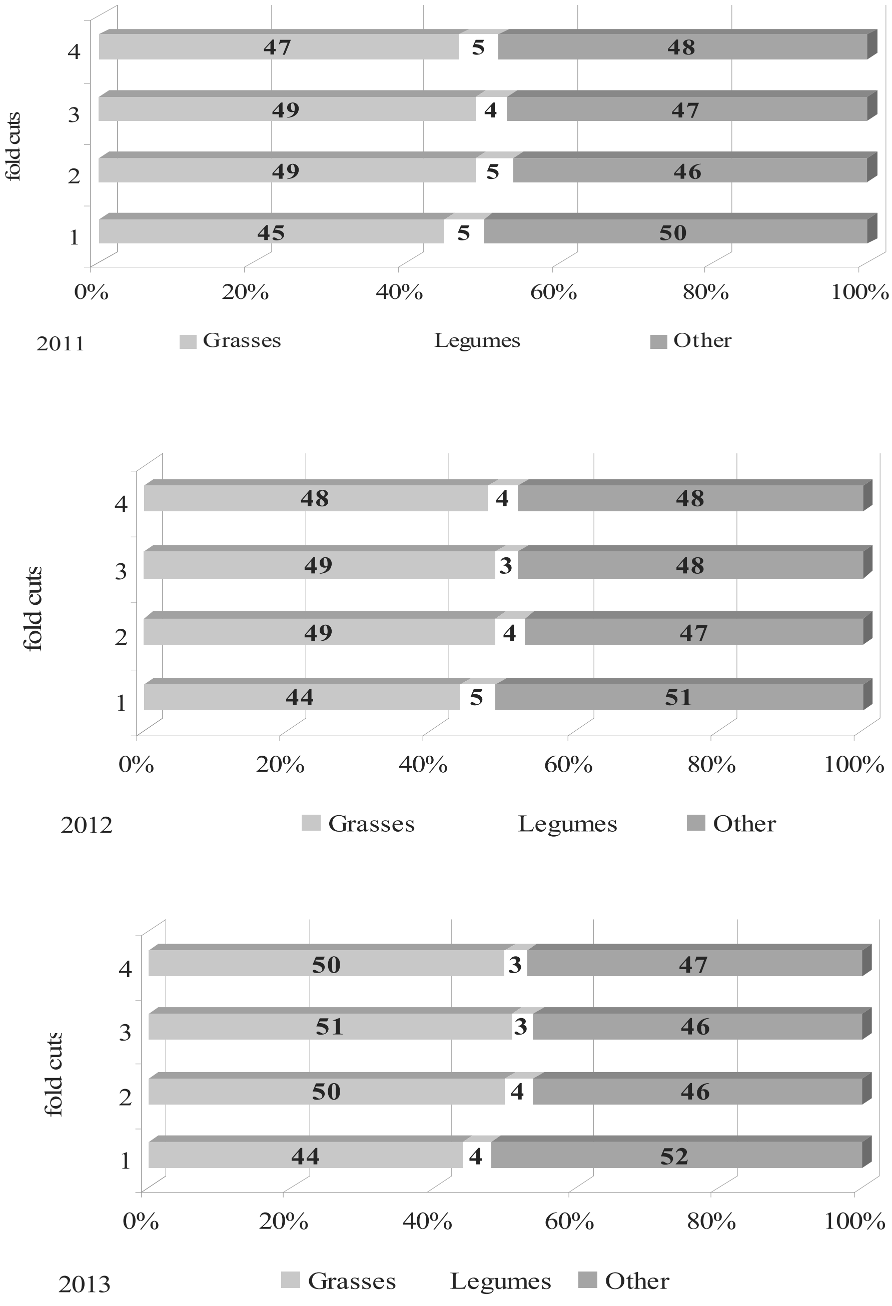

Fig. 1. Floristic composition of permanent meadow depending on the number of cuts (%)

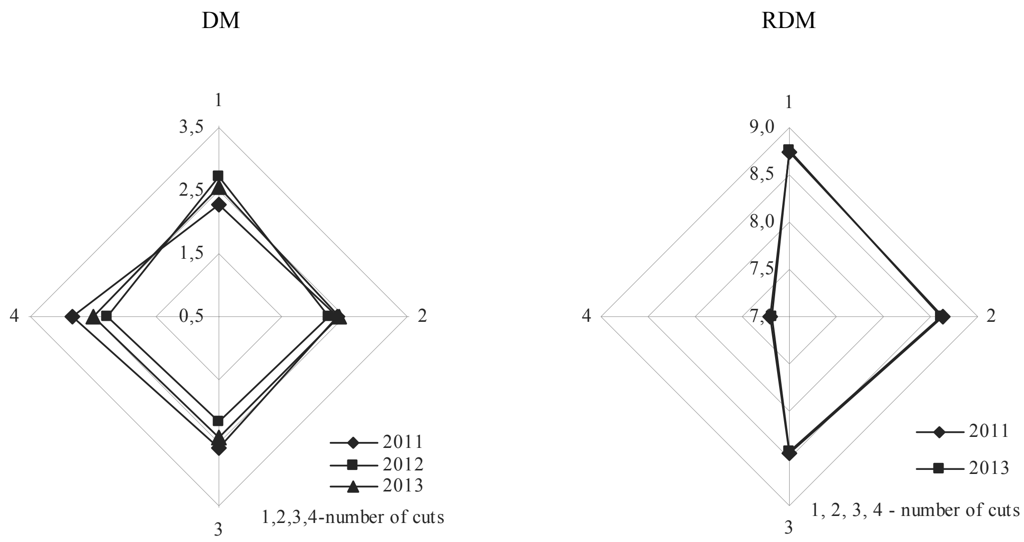

Fig. 2. The yield of DM (a) and RDM (b) of permanent meadow depending on the number of cuts (t·ha^{-1})

Table 2. The relative standard deviations

Item	The number of cuts			
	1	2	3	4
Year 2011				
DM	0.15	0.05	0.08	0.03
RDM	0.16	0.26	0.19	0.14
CP	0.24	0.15	0.16	0.17
CF	0.05	0.06	0.08	0.10
Year 2012				
DM	0.11	0.14	0.06	0.16
CP	0.18	0.14	0.11	0.13
CF	0.11	0.05	0.08	0.07
Year 2013				
DM	0.09	0.08	0.08	0.14
RDM	0.14	0.15	0.07	0.17
CP	0.19	0.23	0.15	0.15
CF	0.05	0.07	0.08	0.09

ration of that experiment, in the meadows where fertilization was ceased, although mowing was continued, there has been seen clearly the reduction of the yield, up to 26.3–26.9% (when cutting 3 times) and to 14.1% (when cutting twice). The analysis of the variance in our study shows, that there are no significant differences between the total dry matter yield depending on the number of cuts, as well as the years of study (Table 3). The hypothesis concerning the lack of interaction between particular factors (the number of cuts and years of research) was rejected at the level of probability amounting p=0.011. This means that those factors interact, which demonstrates the effect of the number of cuts on the total yield of dry mass depending on the year.

Table 3. ANOVA F-test probabilities for the effects of number of cuts, years and their interaction effects

Item	DM	RDM	CP	CF
	p-value			
The number of cuts	0.260	0.124	<0.001	<0.001
Year	0.172	0.975	0.233	0.252
The number of cuts × year	0.011	1.000	0.980	0.044

The root mass is considered the most important stabilizing element of multi-species plant communities. Information on the extent of its variability, in relation to agricultural biomass, makes it possible to assess the resistance of plant communities to the impact of human activity. Therefore, it also shows the ability, to avoid transformations in the period of usage [Fiala 2010]. Cutting of plants usually causes a decrease in root mass, but the same trend is not observed in all types of communities [Fiala 1997]. Zhang and Romo [1994], confirmed that after three years of research, the total dry weight of the root of the *Agropyron dasystachyum* communities, that repeatedly defoliated every six weeks, decreased by as much as 30%. Similarly, Guo et al. [2005] and Chandra and Tanaka [2006], observed a reduction in the length of the grass roots by about 26–45%, and the root mass by 17–18% during the year.

In this study, which was conducted in specific plant community, that possess characteristics of both *Gladiolo-Agrostietum capillaris* and *Anthyllidi-Trifolietum montani*, there was also visible some change in the root mass. After the first year of the study, the RDM decrease was found in a layer of soil from 0–40 cm, on sites with more frequent mowing (Fig. 3). The largest root mass was found in sites which were cut once a year (8.74 $t \cdot ha^{-1}$), comparing to the smallest root mass, that was assessed in the most intensively used sites, which were cut four times a year (7.21 $t \cdot ha^{-1}$). In this case the difference was 17.5%, comparing to the sites with just one cut. The opposite trend was observed for total dry matter yield, as the lowest yield was observed in the plots that have been cut once, and then increased by 5.8, 13.7 and 24.3% respectively in plots with two, three and four cuts per year. The biggest difference between the yield of root dry mass and aboveground dry matter yield, of 6.48 $t \cdot ha^{-1}$, was found in plots with one cutting during a year, the smallest – 4.40 $t \cdot ha^{-1}$, in sites that were cut four times. The widest spread of root dry mass in comparison to the average (RSD=0.26), were calculated in plots which were cut twice, and the smallest (RSD=0.14) on sites with four cuts each year.

After three years of duration of this experiment, the root dry mass yields were not significantly different, from those that came from the beginning of the study. They were mostly smaller, about 0.2–0.4%. The largest yield of root dry mass was found in sites cut once, and the lowest

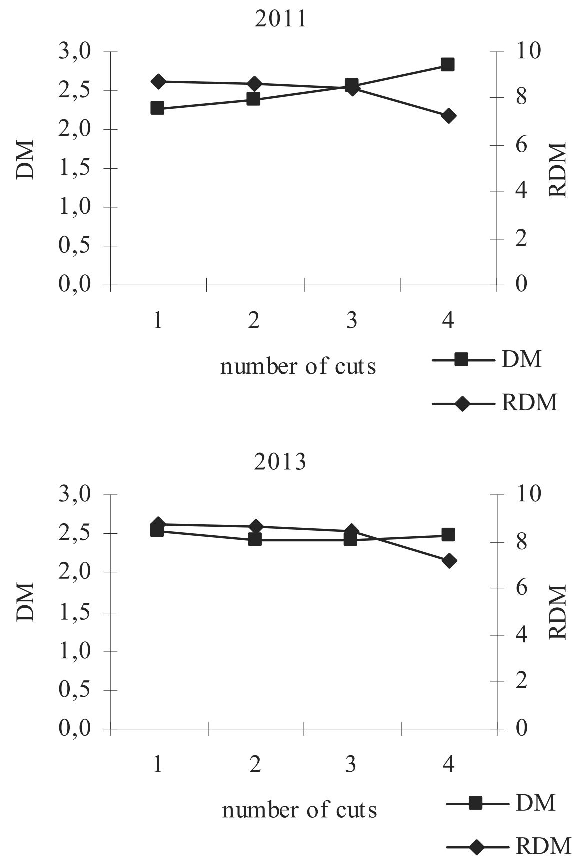

Fig. 3. The mean RDM (t·ha^{-1}) in the sward of permanent meadow depending on the number of cuts

in sites cut four times. At the same time there was a slight and statistically insignificant increase in root mass by 0.2%. However, during those three years of research, cumulative dry matter yields of plants have varied. Thus, the lowest yields were noted in plots, which have been cut two and three times each year, and then higher by 2.5 and 5.0% in plots sequentially cut four times and only once a year. The biggest difference between the yields of dry matter of root and above ground dry matter yields, of 6.23 t·ha^{-1} was found in the sites, which were cut once and then 6.19 and 6.02 t·ha^{-1} in sites with two and three cuts during each year. In comparison, the smallest difference – 4.71 t·ha^{-1}, was found in plots, that have been cut four times.

In 2013, the largest observed variability around the mean (RSD=0.17) was calculated for dry matter yields of root, in sites with 4 cuts per year, while the smallest variability (RSD=0.07) for the crop of root mass, in those plots, which were annually cut three times. The results of the analysis of variance show that there are no significant differences between the yields of dry root mass, both between the number of cuts, as well as years of research. There is also no basis (p=1.000) to reject the hypothesis of the interaction of the considered factors.

The average crude protein content (CP) in meadow plants above ground biomass, was related to the frequency of cuts (Fig. 4). In each year of the study, the lowest average content of crude protein was determined in the sward, which was annually cut once (78.2–91.7 g·kg^{-1}). The average content of crude protein in plants from other plots, that have been cut two to four times each year was higher, comparing to the sward that was cut once a year. That was respectively by 15.5–30.7% for plants cut twice, 27.5–38.7% for plants cut three times, and 37.4–43.7% for plants cut four times a year. According to Pontes et al. [2007], a significant correlation between the yield and dry matter content of CP was found, and confirmed by a Spearman's rank coefficient calculation of 0.91, $P<0.01$.

Furthermore, Duru [1994] claims that the concentration of CP in plants decreases with increasing dry matter yield. Frequent defoliation reduces the yield of the dry matter of grasses and significantly increases the content of the CP, and this is related to the amount of nitrogen in plants [Lemaire and Gastal 1997]. In our experiment, an increasing average content of CP in plants was generally observed, and it depended on the number of performed cuts in subsequent years of the study. In this regard, the exception were plants from the plots that were cut four

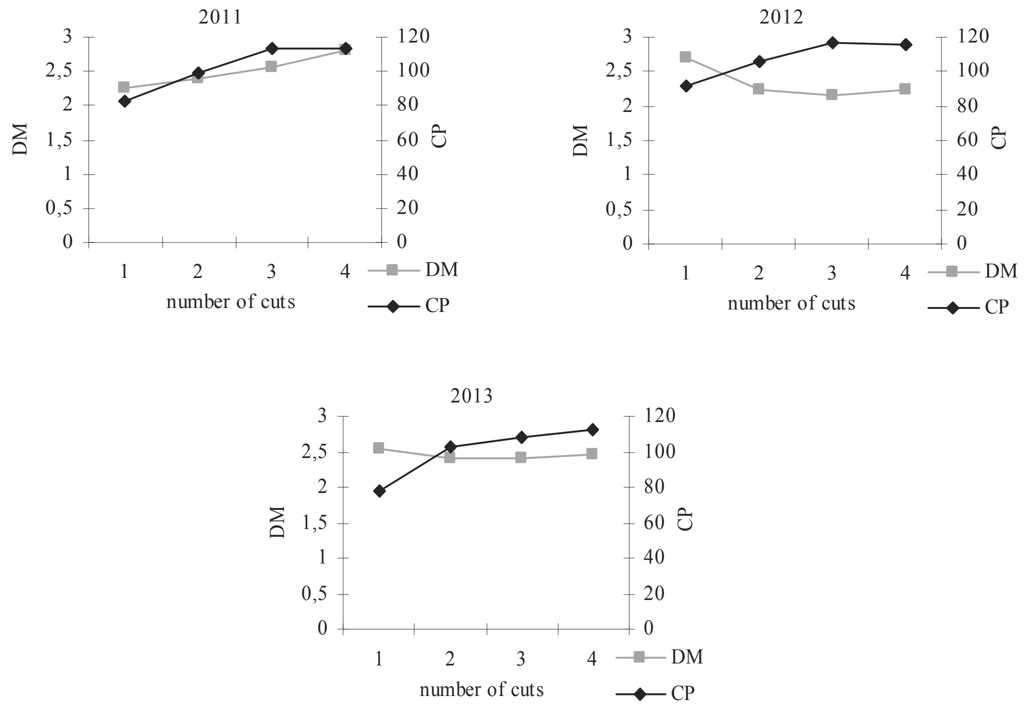

Fig. 4. The mean CP content in the sward of permanent meadow depending on the number of cuts (g·kg^{-1})

times in the first year of the study, which determined a smaller average amount of CP, than for plants in sites which were cut three times. The concentration of protein in the sward, that was cut annually three and four times, coincided with that marked by Bruinenberg et al. [2003], in silage made from the species-poor sward.

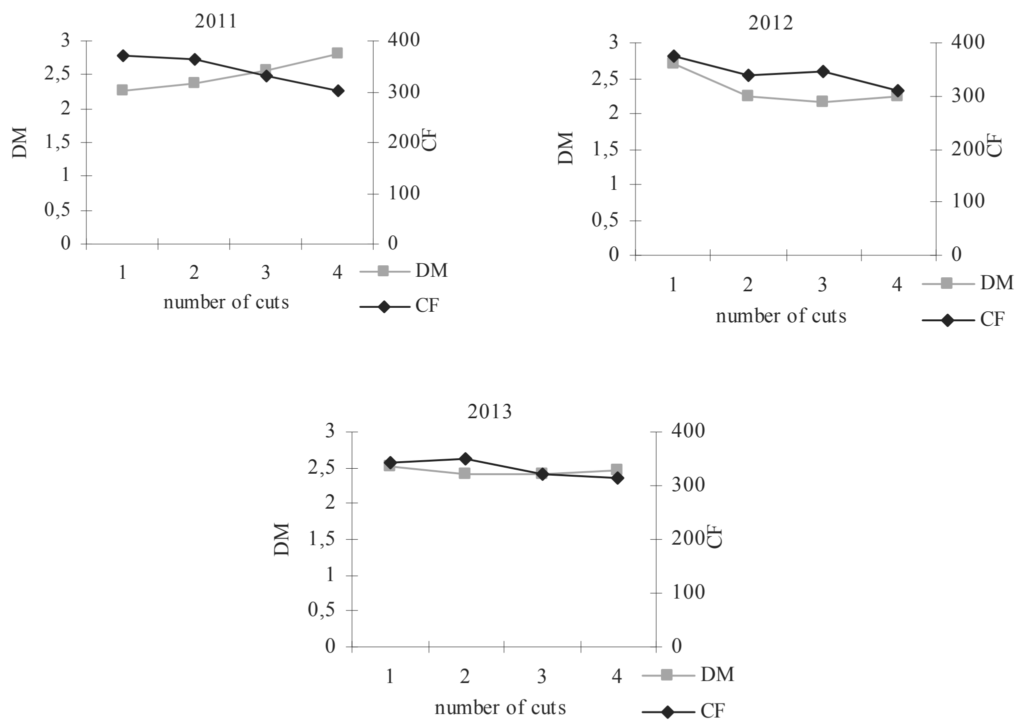

Fig. 5. The mean CF content in the sward of permanent meadow depending on the number of cuts (g·kg^{-1})

Moreover, statistical analysis shows that there were no significant differences between the mean crude protein content during the research period, as evidenced by the estimated value of p=0.233. In contrast, there were significant differences, at the low probability of the test ($p<0.001$), between the mean contents of crude protein, depending on the number of cuts. The greatest variability of the crude protein content in dry plant matter around average was calculated in the sward, which was cut once in the first year of the study (RSD=0.24), and the smallest in the sites where the sward was cut three times, in the second year of the study (RSD=0.11).

Average crude fibre content (CF) in the analyzed plants, was various and similar to the results obtained by Bruinenberg et al. [2003]. In the first year of the study, the highest average amount of CF (369.2 g·kg^{-1}) was determined for plants from those plots, which have been cut once a year (Fig. 5). However, in the sward of sites with: two, three and four cuts per year, it was visible that the average content of crude fibre has decreased. Successively, this was a decrease of: 1.4, 10.0 and 18.2%, while at the same time, the dry matter yields have respectively increased to: 5.8, 13.7 and 24.3%. In the second year of the study, a similar trend in crude fibre content was observed, as in the first year. Namely, the highest average amount of CF was determined in the sward with one cut (374.9 g·kg^{-1}), with a decrease in the CF content of 9.4, 7.7, and 17.4% respectively in the sward sites that were cut two, three and four times. In the last year of the research, the highest average CF content was found in the object with two cuts (351.4

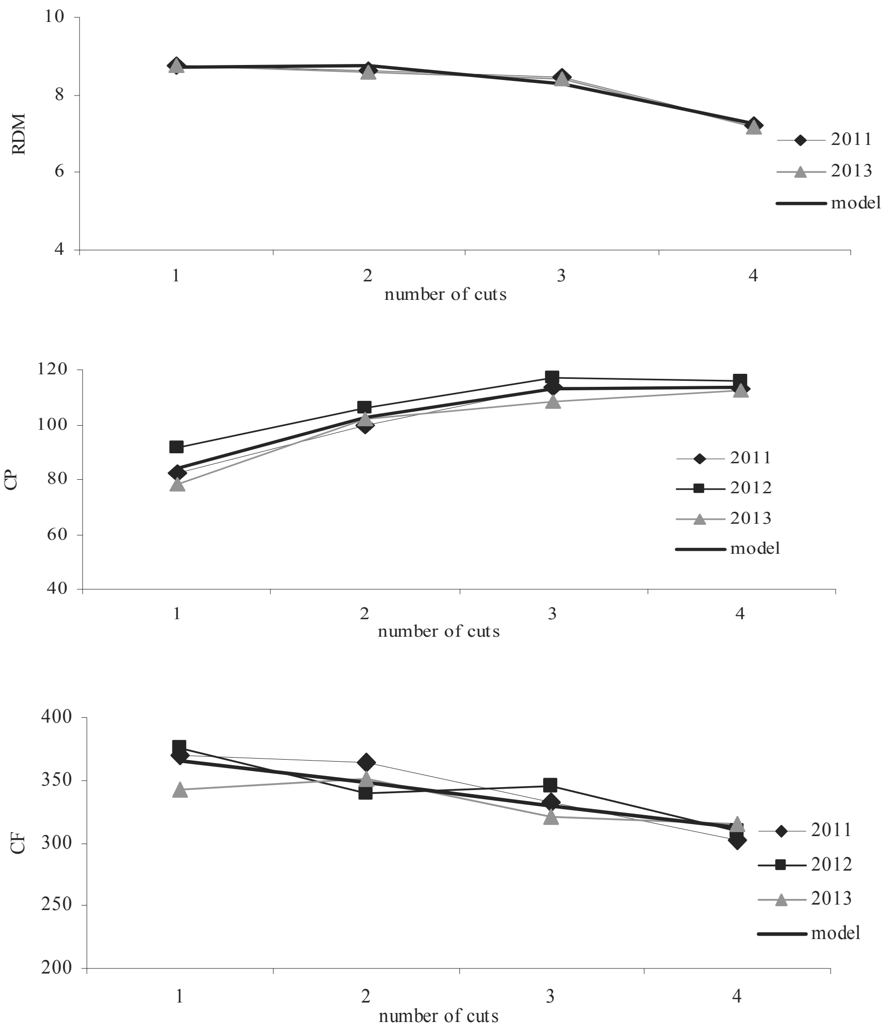

Fig. 6. Mean levels of RDM (t·ha^{-1}), CP, CF (g·kg^{-1}) and the models of change described factors depending on the number of cuts

g·kg^{-1}). The amount of this component was higher by 2.4%, comparing to the content of CF in the sward which was cut only once a year. The sward from plots which have been cut three and four times annually, contained from 6.3 to 8.1% less of the crude fibre, than the sward which was cut only once.

The crude fibre content distribution around the mean was similar in the first and third year of the study. In general, RSD values increased according to the number of annual cuts. The smallest relative deviation was found in the sward cut once, in the first and third year of the experiment (RSD=0.05), and the largest in the sward sites cut four times in the first year (RSD=0.10).

On the other hand, in the second year of the study, the highest relative standard deviation of CF content (RSD=0.11), was calculated in the sward which was cut once, and the smallest in the sward cut twice a year (RSD=0.05). During the study there were no significant differences between mean contents of crude fibre as evidenced by the estimated value of p=0.252. In contrast, there were significant differences in the low probability of the test (p<0.001), between the mean levels of this component depending on the number of cuts.

On the basis on the data, which were presented in the figure 6, that describe the factors that change, depending on the number of cuts (x – number of cuts) to the yield was fitted:

• RDM = -0.29 (+/- 0.11) x^2 + 0.91 (+/- 0.58) x + 8.07 (+/- 0.63), R^2 = 0.97
• CP = -40.89 (+/- 3.3) x^{-1} + 124.66 (+/- 1.97), R^2 = 0.99
• CF = 383.79 (+/- 5.98) x 17.89 (+/- 2.18), R^2 = 0.97.

The estimated coefficients of determination (R^2) indicate good matching to the data model.

CONCLUSIONS

1. After three years of conducting of the field experiment, which focused on different number of cuts in the meadows' sward, without fertilizing, there have been seen a different share of particular fractions of typical meadow sward, that consists of: grasses, legumes, and other dicotyledons species. In the sites that were cut just once a year, there was perceived an increase in the fraction of other dicotyledons, and at the same time slight decrease of the share of grasses and legumes. However, in the meadow sward from the sites that were cut respectively: two, three and four times, grasses dominated and hence, there was observed the decrease of legumes and other dicotyledons species.
2. Depending on the year of the study, there was observed the effect of number of cuts, on the total yield of dry mass, only at a probability level of p=0.011. Whereas, there were not found any significant differences between the mean contents of total protein (CP) and crude fibre (CF) in each year of the research. Also in the low probability test (p<0.001), significant differences between mean levels of these components depending on the number of cuts were showed.

REFERENCES

AOAC 2003. Official Methods of Analysis of AOAC International. 17th ed. Gaithersburg, MD, USA. Association of the Official Analytical Chemists (AOAC) International.

Bednarek R., Charzyński P., Kabała C. 2009. World Reference Base for Soil Resources – WRB. Wyd. Nauk., Toruń: 81–116.

Bruinenberg M.H., Geerts R.H.E.M., Struik P.C., Valk H. 2006. Dairy cow performance on silage from semi-natural grassland. NJAS – Wageningen J. Life Sci. 54: 95–110.

Bruinenberg M.H., Valk H., Struik P.C. 2003. Voluntary intake and *in vivo* digestibility of forages from semi-natural grasslands in dairy cows. NJAS – Wageningen J. Life Sci. 51: 219–235.

Chandra D.S., Tanaka N. 2006. Harvesting aerial shoots of *Zizania latifolia* at different growth strategy: Effects on belowground biomass, regrowth, and rhizome morphology. J. Freshwater Ecol. 21: 583–591.

Donath T.W., Hölzel N., Bissels S., Otte A. 2004. Perspectives for incorporating biomass from non-intensively managed temperate flood-meadows into farming systems. Agric. Ecosyst. Environ. 104: 439–451.

Duru M. 1994. Mineral nutritional status and botanical composition of pastures. II. Effects on nitrogen concentration and digestibility of herbage. Europ. J. Agron. 3: 125–133.
Fiala K. 1997. Underground plant biomass of grassland communities in relation to intensity. *Acta* Sci. Nat. 31(6): 1–54.
Fiala K. 2010. Belowground plant biomass of grassland ecosystems and its variation according to ecological factors. Ekológia 29: 182–206.
Grygierzec B., Musiał K. 2013. Effect of fertilization on the floristic composition and the fodder value of selected indicators of pasture sward. Episteme 18: 147–159.
Guo L.B., Halliday M.J., Siakinotu S.J.M., Gifford R.M. 2005. Fine root production and litter input: its effects on soil carbon. Plant Soil 272: 1–10.
Hansson M., Fogelfors H. 2000. Management of a semi-natural grassland; results from a 15-year-old experiment in Southern Sweden. J. Vegetation Sci. 11: 31–38.
Heinsoo K., Melts I., Sammul M., Holm B. 2010. The potential of Estonian semi-natural grasslands for bioenergy production. Agric. Ecosyst. Environ. 137: 86–92.
Jankowski K., Jankowska J., Ciepiela G., Sosnowski J., Wiśniewska-Kadżajan B., Kolczarek R. 2014. The efficiency of nitrogen from fertilizers in orchard grass cultivated in pure sowing or with the legumes. Romanian Agric. Res. 31: 185–191.
Kondracki J. 2009. Regional geography of Poland. PWN Warszawa: 336–346.
Kopeć M. 2000. Dynamika plonowania i jakości runi łąki górskiej w okresie trzydziestu lat trwania doświadczenia nawozowego. Zesz. Nauk. AR Kraków 267: ss. 84.
Lemaire G., Gastal F. 1997. N uptake and distribution in plant canopies. In: Lemaire G. (ed.) Diagnosis of the nitrogen status in crops, Heidelberg, Germany: Springer-Verlag: 3–43.
Matuszkiewicz W. 2002. Przewodnik do oznaczania zbiorowisk roślinnych Polski. Wyd. III, PWN Warszawa, ss. 536.
Musiał K., Kasperczyk M. 2013. Changes in floristic composition of the mountain pasture sward after the abandonment of sheep grazing. Grassl. Sci. Europe 18: 418–420.
Musiał K., Szewczyk W., Grygierzec B. 2015. The effect of ceasing of use on the flora and plant associations in meadows and pastures of selected parts of the Western Carpathians. Fragm. Agron. 32(4): 53–62 (in Polish).
Nevens F., Rehuel D. 2003. Effects of cutting or grazing grass swards on herbage yield, nitrogen uptake and residual soil nitrate at different levels of N fertilization. Grass Forage Sci. 58: 431–449.
Oleksynowa K., Tokaj J., Jakubiec J. 1993. Przewodnik do ćwiczeń z gleboznawstwa i geologii dla studentów AR. Część II. Metody laboratoryjne analizy gleby. Praca zbiorowa. Komornicki T. (red.). Wyd. 7: ss. 140.
Oomes M.J.M. 1990. Changes in dry matter and nutrient yields during the restoration of species-rich grasslands. J. Vegetation Sci. 1: 333–338.
Pontes L.S., Carrére P., Andueza D., Louault F., Soussana J. F. 2007. Seasonal productivity and nutritive value of temperate grasses found in semi-natural pastures in Europe: responses to cutting frequency and N supply. Grass Forage Sci. 62: 485–496.
Poschlod P., Bakker J.P., Kahmen S. 2005. Changing land use and its impact on biodiversity. Basic Applied Ecol. 6: 93–98.
Radkowski A., Grygierzec B., Kasperczyk M. 2005. Accumulation of flora occurring on the molds in the Malopolska region in relation to the soil moisture levels. Grassl. Sci. Europe 10: 404–408.
Römermann Ch., Bernhardt-Römermann M., Klemer M., Poschlod P. 2009. Substitutes for grazing in semi-natural grasslands – do mowing or mulching represent valuable alternatives to maintain vegetation structure? J. Vegetation Sci. 20: 1086–1098.
Sammul M., Kattai K., Lanno K., Meltsov V., Otsus M., Nöuakas L., Kukk D., Mesipuu M., Kana S., Kukk T. 2008. Wooded meadows of Estonia: conservation efforts for a traditional habitat. Agric. Food Sci. 17: 413–429.
Sammul M., Kull K., Kukk T. 2000. Natural grasslands in Estonia: evolution, environmental and economic roles. In: Conventional and Ecological Grassland Management. Comparative Research and Development. Viiralt R. (Ed.) Proceed. of the International Symposium. Estonian Grassland Soc., 20–26.

Schaffers A.P. 2002. Soil, biomass, and management of semi-natural vegetation. Part II. Factors controlling species diversity. Plant Ecology 158: 247–268.
Smoroń S. 2013. Dynamics of the mountain meadow yielding in period of 25 years after fertilization abandonment. Woda Środ. Obszary Wiejskie 13: 111–120 (in Polish).
Vinther F.P. 2006. Effects of cutting frequency on plant production, N-uptake and N2 fixation in above – and below-ground plant biomass of perennial ryegrass-white clover swards. Grass Forage Sci. 61: 154–163.
Wallis De Vries M.F., Poschlod P., Willems J.H. 2002. Challenges for the conservation of calcareous grasslands in northwestern Europe: integrating the requirements of flora and fauna. Biological Conservation 104: 265–273.
www.tutiempo.net/clima/polonia
Zarzycki J., Szewczyk W. 2013. Impact of abandonment on the floristic composition of permanent grassland and grassland created on former arable land. Grassland Sci. Europe 18: 421–423.
Zhang J., Romo J.T. 1994. Defoliation of a northern wheatgrass community – aboveground and belowground phytomass productivity. J. Range Manag. 47: 279–284.

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PLONOWANIE I JAKOŚĆ SEMI-NATURALNEJ RUNI ŁĄKOWEJ W ZALEŻNOŚCI OD ILOŚCI WYKONANYCH POKOSÓW

Synopsis. Celem niniejszego badania była analiza dynamiki plonowania i jakości nienawożonej runi łąkowej w latach 2011–2013. W doświadczeniu polowym oceniano ruń 4 obiektów, którą koszono odpowiednio: raz, dwa, trzy i cztery razy w roku. Oceną objęto plonowanie, zawartość białka ogólnego, włókna surowego oraz ilość masy korzeniowej. W zależności od roku badań stwierdzono wpływ ilości wykonanych pokosów na sumaryczny plon suchej masy wyłącznie przy niskim poziomie prawdopodobieństwa testowego p=0.011. Natomiast nie stwierdzono istotnych różnic między średnimi zawartościami białka ogólnego (CP) oraz włókna surowego (CF) w latach badań. Także przy niskim poziomie prawdopodobieństwa testowego (p<0.001) obliczono istotne różnice między średnimi zawartościami tych składników w zależności od ilości wykonanych pokosów.

Słowa kluczowe: skład botaniczny, plony suchej masy, masa korzeniowa, białko ogólne, włókno surowe

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